In-Car GPS Navigation: Engagement with and Disengagement from the Environment

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ABSTRACT

Although in-car GPS navigation technology is proliferating, it is not well understood how its use alters the ways people interpret their environment and navigate through it. We argue that GPS-based car navigation might disengage people from their surrounding environment, but also has the potential to open up novel ways to engage with it. We present an ethnographically-informed study with GPS users, showing evidence for practices of disengagement as well as new opportunities for engagement, illustrating our findings using rich descriptions from the field. Grounded in our observations we propose design principles for GPS systems that support richer experiences of driving. We argue that for a fuller understanding of issues of disengagement and engagement with the environment we need to move beyond a focus on the (re)design of GPS devices, and point to future directions of work that embrace a broader perspective.

ACM Classification Keywords

H5.m. Information interfaces and presentation (e.g., HCI): Miscellaneous. K4.2. Computers and society: Social issues.

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GPS, environmental engagement, qualitative field study.

INTRODUCTION

At this point in time, only a fraction of drivers in the United States regularly use GPS units for in-car navigation. But many of those who do embrace the technology: "*It is just a lifesaver! I am never lost now.*" (Informant F, April 2007) With the use of GPS technology for in-car navigation, new practices for finding one's way in urban spaces and on the highway develop, and the social dynamics involved in a road trip are transformed: "*it used to be that whoever wasn't driving was the navigator... And so if there was a mistake made, the navigator would say 'Turn! Turn!' and it would be drama. But now, if you miss a turn... it's just*

automatic." (Informant T, April 2007)[1]

Our aim in this study is to raise awareness of how the proliferation of in-car GPS technology alters users' experiences of their environment. In particular we want to explore questions of how the practice of driving and navigating with this technology changes the ways that people feel, think about, and engage with the physical and social spaces they traverse through and places they encounter. Albeit the importance of human factors and ergonomics perspective for the research and design of in-car GPS systems (as few examples see [8,9,16,18,19]), this paper is not about performance, safety, or efficiency. Instead, we offer additional perspectives to the research and design of GPS units, including experience, interpretations, and socializing.

Several researchers have argued that navigating with GPS devices supports only a reduced, disembodied understanding of landscape [17], hinders the development of cognitive maps, and results in poor reconstruction and memory of the environment through which one is driving [8.12]. GPS navigation units have been identified as paradigmatic examples of Borgmann's [4] fundamental critique of technological devices: that they demand less skill and attention by providing orientation and navigation as a commodity, with instant availability, ubiquity, safety, and ease of use, and as a result their use results in a loss of engagement with the environment and others [2].

On the other hand, having orientation and navigation delivered as a commodity frees drivers and car passengers from a task that can be cumbersome and consuming, thereby offering added degrees of freedom and new opportunities for engagement with the outside world. As Dourish argues, the fact that in-car GPS navigation systems provide a virtual representation of a physical space (the grid of streets and coordinates) does not imply the emergence of a separate, detached world with a distinct sphere of practice [11]. Maps, for instance, are technologies that aid in navigating and wayfinding, and their use reveals complex practices of engaging with the surroundings rather than disengaging

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[1] Although we carried out our observations in the United States, many of our arguments are based on findings of studies carried out in other countries, e.g. UK-based studies by Gary Burnett, Barry Brown, and Nick Forbes.

with it [5]. The technologically-mediated space in this way of thinking essentially provides new opportunities for appropriating the physical world as part of everyday practice.

We here present a field study that highlights incidents of environmental engagement and disengagement while using in-car GPS devices, i.e. in navigating to a destination, maintaining orientation in the physical world, attending to landmarks along the way, and socializing with other people inside and outside of the car. We find evidence for disengagement, but also observe opportunities for new forms of engagement. We suggest including environmental engagement in the design goals for GPS navigation devices, and suggest design principles that encourage user interactions with the environment to lead to a richer, more engaged driving experience.

The approach taken in our empirical study can be framed within a device-centered analysis of technological change. We will review the relevant theoretical context in the next section. A device-centered perspective though falls short of a full appreciation of the scope and interlinkages of changes to environmental engagement as they evolve with the use of novel mobility-enhancing technologies. Hence we will conclude our paper with a discussion of these broader dimensions and their implications for future follow-up work.

DEVICE-CENTERED INTERPRETATIONS OF TECHNOLOGY CHANGE

In this paper we are interested in what GPS technology means for our experiences of the environment that surrounds us. Following debates on GIS systems in geography, we discuss two perspectives to analyze the complexities of changes created by the introduction of new technologies, namely losses vs. opportunities, and full-circle analysis. These approaches serve as a theoretical framework for our empirical analysis of environmental engagement as it is altered with GPS navigation practices.

When setting out to critically examine how a new technology changes our experiences of and engagement with the world, we were careful to avoid two possible pitfalls. First, we were wary about assuming *technological determinism*, i.e., perceiving technology as an autonomous, external force imposing societal change. This would suggest that GPS technologies have a concrete and deterministic effect on users' engagement with the world that arises from their functional structure without regard to user appropriation and social forces involved in shaping technologies. Second, we were careful to avoid *romanticizing the traditional*, which would suggest that if GPS technologies alter human behavior, this must necessarily be for the worse. Instead, we acknowledge change and adaptability as inherent properties of human societies. In effect, any state of affairs in the past that gets identified as traditional represents only a single instance in a continuum of change. As Aporta and Higgs emphasize in their study of GPS use among Inuit hunters, "*the common image of Inuit traditional culture is nothing but a particular (and arbitrarily frozen) period in the his-*

torical development of Inuit peoples" [2]. Examination through the lenses of losses vs. opportunities and full circle analysis helps to work against these perspectives.

Losses vs. Opportunities

Based on an extended ethnographic field study, Aporta and Higgs provide a convincing account of how the uptake of GPS systems for navigation by young, inexperienced Inuit hunters replaces traditional Inuit wayfinding practices that require a detailed knowledge of, and skilled engagement with the environment [2]. A similar, if less drastic case, can be made for the use of in-car GPS navigation systems in urban or suburban environments. GPS relieves the car driver and passengers of the need to closely observe the environment, to look out for road signs or landmarks, to orient with respect to where they are located, and to memorize a chosen route for future reference. Instead it offers orientation and navigation as a commodity: anywhere and anytime. Thanks to GPS, "*engaging with the environment becomes a matter of choice*" [2].

From a perspective of technological determinism and cultural pessimism we would interpret this observation of altered practices as manifestations of an inevitable loss of engagement with the environment. Dourish instead encourages us not to look at space as pre-given, but to recognize both space and place as "*products of embodied social practice*" [11]. As the introduction of new technologies generates new practices, new forms of spatiality arise, with new opportunities for engagement with the environment.

This calls for balancing the recognition of inevitable loss of traditional ways of engaging with the environment with attention to the changes in practices that produce new forms of spatiality, and hence new forms of environmental experiences. To what extent these new opportunities of personal mobility can be realized, though, depends on social and political circumstances. Dourish warns against focusing on the "*young, well-heeled, techno-savvy [...] engaged in discretionary (often somewhat predatory) movement through and consumption of urban space*". Their perspective contrasts sharply with experiences of homeless people, moving to avoid encounters with authorities, of taxi drivers, for whom mobility is labor, or of commuters, spending hours traveling between home and workplace [11]. So we need to ask, what new opportunities are acquired, and by whom?

Full-circle analysis

The discipline of geography has seen extended debates on the social implications of Geographic Information Systems (GIS) over the last fifteen years. Chrisman [10] critically observes that the focus on 'implications' reveals a deterministic bias that assumes technology can be studied "*in isolation, removed from its construction or its use*". Along with Oudshoorn and Pinch [21] he argues that this perspective neglects the active role users play in co-constructing technology. Instead, Chrisman suggests a perspective that recognizes GIS technology as brought forth in a social con-

struction process – when the technology is created as well as when it is configured and adapted for specific applications: "*GIS is pervaded with social (disciplinary, economic, political etc.) influences, and […] these are not necessarily evil, but the very reasons for doing GIS in the first place... By turning full circle, connecting from social needs to technical issues, then back to the social realm, we avoid the flaws of isolating implications from their causative environment*" ([10], p. 31/32).

Chrisman points out that by adopting a full circle perspective we are under a greater ethical responsibility as it recognizes the ability of individuals to resist specific directions, of users to reject or re-design technology, and emphasizes choices that can be made. Hence, looking at the use of GPS devices is only one aspect of understanding the changes they bring about. For a more complete picture one would want to look at the social processes that are influencing and are influenced by these devices, and how they feed into their design and production. In bearing with the full-circle approach, as we show later, our empirical observations can feed into the re-design of GPS systems, thereby underlining the ethical responsibility to take an active role and make informed choices instead of succumbing to the force of an allegedly independent technological development.

In the next section we present an empirical study of in-car GPS navigation system users. We adopt an approach that considers losses of and opportunities for engagement and applies a broader perspective of the full-circle analysis of GPS design, use, adaptation, and appropriation.

FIELD STUDY OF GPS USERS

Experiences of Space and Place
In the following we set out to examine empirically how people experience the environment during activities of navigating and driving with GPS. The notion of experience and awareness of the environment that surrounds GPS users is examined through concepts of *space* and *place* as they are introduced by Tuan [29]. Yi-Fu Tuan, a cultural geographer, defines space and place in relation to each other:

> *"Space" is more abstract than "place." What begins as undifferentiated space becomes place as we get to know it better and endow it with value. […] From the security and stability of place we are aware of the openness, freedom, and threat of space, and vice versa. Furthermore, if we think of space as that which allows movement, then place is pause; each pause in movement makes it possible for location to be transformed into place. (p. 6)*

Tuan offers insight into how people learn, navigate, interpret, and experience spaces and places in which they exist. On one end is a rich, direct and intimate experience and knowledge that is hard (but not impossible) to articulate, and on the other end an indirect and conceptual, easier to communicate knowledge. Arguing that most geographical accounts offer the second perspective, Tuan claims that "*the*

rich experiential data on which these abstractions depend are easily forgotten." As an alternative, he offers an experiential and cultural perspective of developing certain meanings of spaces and places in which we live.

Tuan claims that participation in the environment allows for the creation of a sense of place, giving objects their personality and transforming blurred geometrical spaces into meaningful places. Harrison and Dourish also refer to the process of valuing a space and as such turning it into place [14]: "*A place is generally a space with something added – social meaning, convention, cultural understandings about role, function and nature and so on.*" Active participation and engagement, such as building a house or interacting with people, increase awareness of objects in the physical environment and generate valued attachment to them.

However, active participation in the physical modern world is much reduced. For example, most people no longer build their own houses and many less interact with their neighbors. Furthermore, modern society is increasingly literate, depending less on physical and material objects in the environment and more on virtual symbols (books, the Web) to embody the value and meaning of our culture. Similarly, despite Brown & Perry's claim that *"systems should support a sense of embodied location"* [6], GPS technology, with its coordinate system, navigation directions, map displays, and array of settings, provides an abstract representation of the physical environment. This suggests that depending on GPS for navigation may replace embodied mundane experiences of the world with conceptual abstractions of it.

This leads us to the possibility that navigating with GPS inherently would lead to shifts in engagement with the environment. Tuan's terminology would suggest that using GPS alters the process of turning our surrounding environment from space into place. Rather, *place* becomes those objects within the GPS technology, while physical objects in the environment remain indistinct from each other.

Method
The examination of GPS navigation in this paper is based on the analysis of in-car GPS use accounts. Existing studies of GPS navigation are typically interested in usability issues, and their methodologies fall into experimental formats [8,19]. Interested in people's everyday practices, experiences, and interpretations with GPS navigation, we chose a different approach, similar to studies which aim at understanding mobility practices with technology devices [15, 27]. We decided to pursue an ethnographically-informed study, through observations and interviews with GPS users.

Along with several colleagues, we carried out observations with ten in-car GPS navigation device users, whom we contacted personally and requested to participate. Our informants were between the ages 19 and 40 (Median=27), and

nine of them were males[2]. The GPS devices used by our informants were of different types, and they were owned either by the informants, or by their friends or relatives.

Sessions typically included a researcher taking a ride in the car with an informant driving it. In five sessions we joined trips already planned by the informants. Four of these trips were on highways and rural roads in Upstate New York, including a commute ride, two visits to friends and family, and one trip for work purposes. One trip included driving around Seattle, picking up friends and going out for dinner and to the movies. In two of the pre-planned rides there were other passengers in the car besides the researcher. The other five sessions included artificial trips in Upstate New York, where we gave the informants a destination and asked them to drive there. For safety reasons, we avoided asking in-depth questions during the drive, and at the end of the ride probed for further information through semi-structured interviews. Each informant participated in one session, lasting approximately 1-3 hours.

Despite the small sample of users, we ended up with rich data, consisting of audio recordings, jottings from the field, transcriptions, and written fieldnotes spanning over hundreds of pages. The analysis of the collected data consisted of careful reading of the different materials and marking parts that seem related to issues of environment engagement and disengagement. We also listened to the recordings and transcribed parts that seem relevant to us. We then organized the relevant parts into common themes, and coded the documents using the themes that emerged.

Results

In the following we report on issues of environmental engagement and disengagement. We organize the presentation of our observations into three subsections: practices of navigation, orientation, and driving. Wherever reference is made to a specific informant, their first name initial is used as key identification.

Navigation
Pre-navigation/Route Choice. We were interested in how the navigator, using a GPS device, chooses which path to take in order to get to his or her destination. Given that the GPS "knows" the current location and assumes that it is the origin of the path, the user only needs to state the destination of his or her travel. This is typically done by keying in the address, sometimes using suggestive menus, including the name of the place (e.g. restaurant name), street address, city, and state, or a combination of these. One Informant, S, did not know the exact street address, but knew that a hotel that exists in the GPS database is located nearby his desti-

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[2] The under-representation of females might be related to other gender/technology issues, and seems common in studies of GPS users: Svahn included 45 males and 13 females [26], and Forbes had 10% female participation rate [12].

nation, and so pulled it up as the destination. Interestingly, the users need not know where the destination is spatially located relative to the origin: whether it is north, south, east or west from where the user is currently standing. "Finding" the destination is thus modified from a relative spatial activity to correctly keying in the address.

Once the destination is found, the GPS calculates an "optimal" route, typically given speed limits and distances. Some informants reported that the GPS gives several routes from which they can choose, and they sometimes chose a route based on familiarity with or knowledge about the routes. However, when users had no experience with the route, they chose it based on time to reach their destination. Unfamiliarity with the route led sometimes to unexpected experiences, for example, when D drove through an unfamiliar neighborhood instead of through the center of the city to reach a Medical Center, or when T felt uncomfortable to follow a dirt road, prompting him to ask: "*Where are you taking me?*" As another example, Z reported: "*it gave us some bizarre routes to get back to Ithaca…turns out that the toll road setting was on (laughs). I ignored it…and we figured it out later.*"

Toll roads, secondary roads, and city centers are merely settings for the GPS, whereas for the driver they symbolize embodied experiences within the environment that cannot be simply abstracted into settings. Although there have been attempts to personalize route selection based on user preferences [23], existing GPS routing algorithms do not have the capacity of capturing the lived experiences of deciding how to get somewhere, as G expressed: "*I wish it would just learn that in general we don't mind smaller roads… And so if you were going to some place that was sorta similar to where you went before, so lets say we were again going to Rochester that it might learn what we preferred the last time.*" But as T said, this does not mean that the GPS is necessarily "wrong", "*she [the GPS] just has different ideas about what's right.*"

Route Following. What are the experiences GPS users undergo while navigating toward their destination? One definition Tuan provides for the term *place* is "*whatever stable objects catches our attention*" (p. 161). So, how do GPS users attend to objects in the paths they take toward their destination? We discovered that GPS eliminates much of the need to pay such attention. Users can blindly follow the visual and vocal instructions provided by the GPS and reach their destination. Our observations frequently showed such patterns of interaction. Some participants listened to the vocal instructions and followed them, without knowing where they are or questioning whether the instructions are correct. For example, A said that as long as he has the GPS he neither has the need to be familiar with the roads, nor does he even look at the road signs. Instead of learning the route or using other navigation aids, drivers using GPS need to learn to follow the instructions correctly. As G said:

"The only thing you have to do with the nav system is you have to learn what a quarter of a mile feels like, you know, otherwise it says a quarter of a mile and you think 'Oh, I need to turn!' and you turn too soon. But it helps you once you learn it because it tells you, you know, 'right turn in a quarter mile' and you look at the screen and it tells you the street you're going to be turning on and so then you know its a quarter mile and you can look for a street sign that says 'Smith Avenue' or whatever. So it's really helpful for people who don't read maps well actually."

The previous quote demonstrates a common practice of some informants *not* to follow blindly the vocal instructions. Listening to the voice and glancing at the map on the screen together assisted in making decisions while navigating, as when S looks at the map to learn the curvature of the road to set his driving speed. But using the map was not just for navigation and making driving decisions, as T expressed: "*So it's not like 'turn left in 300 feet' [in a dominating voice]. I like seeing it. Maybe that's a mapping from my experience from the physical world. Holding the map.*"

We found that while a few informants never use other navigation aids, others are reluctant to only rely upon the GPS, and they take with them road maps, printed instructions from online services such as MapQuest and Google Maps, and even a compass in remote landscapes overseas. However, having the GPS at hand turns the other navigation aids into backup services, "just in case" the GPS fails.

Orientation
Orientation in Unfamiliar Areas. To what degree does the GPS user know where he or she is while driving through unfamiliar spaces? For drivers with a poor sense of orientation or who find it difficult to read a map, the GPS is a life saver for not getting lost anymore. F reported that with the GPS, his wife feels safe to explore new places around the city, and "*if she gets lost, all she needs to do is push 'home' on the GPS and she will know how to get back.*" For Z, although he does not know where he is, is not familiar with the neighborhood, and does not know which way to go, he never feels lost because the system will always eventually take him to his destination. A similar sentiment is expressed by D who proclaims that he has a bad sense of orientation and easily gets lost even on routes he has done a hundred times: "*it makes me much more confident to know that if I get lost I can find my way home again. I don't have to stress out about getting lost anymore*". Without the GPS, Z said he "*would be screwed.*" H described this in terms of the control the GPS has over him in areas he is not familiar with. By that, the GPS disconnects the drivers from the external environment, as they no longer need to find out where they are in order to avoid getting lost or for getting oriented when already lost. This issue is intensified when the GPS automatically and quietly recalculates a new route when its directions are not followed unintentionally (e.g. because of a mistake) or intentionally (e.g. because of road constructions and detours): the practice of re-orienting and consciously re-routing oneself is not necessary anymore.

However, some informants reported that they do like to know where they are, and they do so by glancing at the map on the GPS screen, using additional navigation aids, and learning the route in advance before setting out to the road. Justifying hitting the road with printed Google Maps instructions, T said: "*it would be better to know where you're going instead of just listening… to [the GPS system].*" Another practice to get oriented is to zoom the map out, as B and S demonstrated, to get a sense of the landscape and landmarks in the area in which they were driving.

Orientation in familiar areas. Although the GPS is primarily designed for navigation in unfamiliar areas, our informants reported that they largely drive in areas they are familiar with, such as when commuting, going to visit friends, or running routine errands. T said that sometimes he disagrees with the GPS, choosing routes that are less efficient based on his familiarity with them. Both H and Z said that they find the directions "*annoying*" in familiar neighborhoods or on known routes and choose to turn the voice off. However, they both like to see the map so they keep the GPS on without the directions. D reported that he puts up the map of the GPS without the instructions when driving to the grocery store, to a pub, or to friend's house, "*just for fun*" and to estimate distances in town. This enables him to feel in control by locating himself on the map, as well as orienting in the physical environment.

Some informants also reported marking places they know on the GPS map. T, a college student, reported: "*I also use it to mark certain places, save landmarks, like, my house. I've started making little, the exact coordinates for specific places on campus, but that's just for kicks.*" H also liked the idea of marking places he has been to on the GPS. Using the GPS in a familiar place even helps get to know it better, as T said: "*coming home from Collegetown, turns out we discovered a better route home.*" These accounts go back to the concept of active participation introduced by Tuan, which facilitate the emergence of a sense of place. Alternatively, they illustrate blurring of the virtual and physical spaces in which the individual is acting, engaged a little more with the technological environment and a little less with the material environment.

The Experience of Driving
Social Interactions around the GPS. GPS units are designed for a one-on-one interaction between the driver and the technology. As a result, we found that interaction with other passengers in the car has altered given in-car GPS units. With vocal directions from the GPS unit, a passenger who serves as a navigator in the car is no longer in need, and so the driver/navigator roles are modified, as G noted: "*when you have two people in the car, is not that different than when you're by yourself.*" In another incidence, a back-seat passenger asked the driver how far they were, and upon saying he doesn't know, she exclaimed: "*[A], you*

should know!" She seemed to think that the interaction between the driver and the GPS assumes his responsibility to keep track of the route when, in fact, he was not.

Alternatively, we have seen that the passenger riding next to the driver sometimes received the role of interacting with the GPS, in terms of switching settings and displays and pulling up information. Some in-car systems do not allow much interaction while driving for safety reasons [9], and two informants commented on that, wishing that when the car senses that the non-driving passenger is present, it would allow him or her to interact with the system.

Treating the GPS as an Active Agent. An interesting finding was treating the GPS unit socially, almost as another passenger joining the ride. Some informants named their GPS systems, others interacted with their unit using voice recognition. When F, in the driver seat said "*Go home*", R, a passenger in the car, was confused: "*Oh, I thought you were talking to me.*" F talked about the GPS in a social way, noting that he likes to "*tell it to do something and it does and it talks back.*" T, who named the GPS "Heather" and referred to the device as "she", also had "conversations" with the GPS unit although it did not incorporate voice recognition. This point also illustrates how the social dynamics in the car during the ride has been altered given the existence of GPS.

Interaction with the external environment and locals. The GPS affects interactions not only inside the car, but also with the physical environment outside the car. Informants showed us how they pull up points of interest on the GPS map in order to discover restaurants, gas stations, parking garages, and hospitals. Once these places are mapped on the screen, the GPS shows the way to the physical location, as H said: "*when we were driving and we wanted to get coffee for example, right, so we just plug in... and what it does, it shows us Dunkin' Donuts and it shows us how far we'd have to go to get [...] and then it has this icon that says if it's off of my route or if I have to go outside of my route to get it, and how far to go.*" This again creates some blurring of the physical environment with the virtual environment, as the virtual environment becomes the primary environment with which the user engages, and in response decontextualizes the physical space. For example, when S touched the screen to pull up restaurants on the map, he pointed at the screen and said: "*There is restaurant... [pause, looks outside] I don't know where there is restaurant. Maybe the upgraded model has more accurate information.*" S also reported using the curvature of the road in the GPS map to set his driving speed in a low visibility situation in the rain forest in Puerto Rico. Again, this exemplifies the blending of the virtual and physical environments, with the driver relying on the GPS representation of the road rather than on his own unmediated perception of the physical road.

Alternatively, this capability of the GPS has the opportunity to enrich engagement with the physical environment. R enthusiastically pointed out that he discovered rivers and state parks running along his usual routes he did not know existed. H reported that he puts up a layer on the GPS map with Halal food places (prepared according to Islamic law). Wherever he goes, he can find Halal food, and this creates a comfortable feeling even in areas he is not familiar with, creating a sense of place in an otherwise indifferent space.

Finally, with the GPS the driver no longer needs to interact with other people for help in navigating, as F expressed: "*I don't need to call someone and ask them the route...which can get really complicated when you do not know where you are in the first place.*" Interaction with local people is also not necessary with GPS, as illustrated by D's saying: "*Remember when we all went white water rafting? We were in this really small and strange town and the GPS found us a place to eat.*" This issue is also demonstrated in the following dialog between one of the researchers (H) and T:

> T: [...] I wouldn't want to be here without [the GPS].
> H: What would you do without [the GPS]?
> T: I would stop at that house to get help.

Discussion

The results of our field study show how drivers using GPS interpret, learn, navigate, and experience spaces and places in which they interact. We found evidence for loss of environmental engagement: with the GPS you no longer need to know where you are and where your destination is, attend to physical landmarks along the way, or get assistance from other people in the car and outside of it. The reduced need to feel oriented, keep track of locations, and maintain social interactions regarding navigation issues inhibit the process of experiencing the physical world by navigation through it. As such, the process of interpreting the world, adding value to it, and turning space into place is reduced to a certain extent and drivers remain detached from the indifferent environments that surround them.

However, we also found evidence for GPS units providing new opportunities for engagement with the environment. Discovering landmarks otherwise invisible from the road, exploring previously unknown areas thanks to a new sense of security, and interacting with the GPS units as if they are animate are examples of new practices that arise around this technology. Furthermore, GPS units support making sense of the physical world through examples such as locating Halal foods and indicating familiar places such as 'home' and 'work' on the GPS map, thereby increasing the comfort level in both familiar and less familiar areas. These examples suggest that in some cases the GPS can promote environmental engagement rather than hinder it.

But the effects of using GPS are more complex and subtle than mere loss of engagement and opportunities for engagement. GPS users engage with the physical environment in the car and outside of it, but they also engage with the virtual-technological environment offered by the GPS. Our data suggest that in some cases GPS users become im-

mersed more in the virtual-technological environment and less in the physical environment. That is, their primary interpretation process of objects in the world is guided through information provided by the GPS, e.g., when setting their speed based on the route represented by the GPS, not their direct visual perception of the street outside, and when blindly following directions to reach the destination. However, this immersion can also guide further, meaningful interactions with the physical world, promoting exploration and new opportunities for social interactions. As such, the blurred boundaries between the physical and the virtual worlds offer new practices "*not by creating a distinct sphere of practice but by opening up new forms of practices within the everyday world, reflecting and conditioning the emergence of new forms of environmental knowing.*" [11]

As an addendum to our study, we interviewed M, an artist who uses a handheld GPS device for hiking and to document artwork pieces he creates out in the woods. The blurred boundaries between the physical and the virtual-technological worlds are reflected in M's account. He described to us how GPS coordinates provide specificity to the locations of his artwork, but was also aware of the abstraction within GPS technology that jeopardizes taking over experiences in the physical world:

> "*It's still a very abstract process, it's still a very abstract set of calculations, or numbers, or this nomenclature, because it's not the reality of the thing. It's still, there's abstract disconnection of actually being in the place or at the site, you know, and being aware of the history of that site and at that place... it can't be the thing, because if it was you would be there.*"

> "*I've used it for my work over the last couple of years, because, as a tool in that respect. But in some levels that's different than trying, than thinking about my relationship to the world and nature and when I'm off hiking, and whatever, do I really need to be reminded that I'm right here at this particular point, and there are satellites out there that can figure out where I am. There is something about, in a sense, abstracting and dehumanizing about that process a little bit. It doesn't, it makes me want in a sense say, 'enough of that'.*"

Taking a full-circle analysis approach, our results also demonstrate that the relationship between users, GPS technology, and the environment are not necessarily unidirectional. For instance, instead of independently examining the setting of toll roads in the GPS unit, we think about the concept of driving through toll roads or avoiding them, and the design of the GPS units to foster such behaviors. As another example, the design of GPS unit so that interacting with it while driving is impossible is rooted in a narrow perspective that only takes into consideration safety issues. Safe driving should be top priority, but it should also not ignore a view of social dynamics in the car with passengers aiding the driver in navigation. We suggest that the design of in-car GPS units should take these considerations into account, influencing and being influenced by issues of environmental engagement.

DESIGN IMPLICATIONS

In his critique of technological devices, Borgmann articulates his concerns about devices' innate potential to become central metaphors [4]. Today, supporting travel efficiency, for example by identifying best routes, rerouting, avoiding toll roads, etc., is recognized as the central goal for GPS systems. In contrast, connecting to one's environment is not necessarily seen as design goal and therefore is marginalized as system features. Inspired by Agre's call to innovate by explicitly designing for the margins of technical practices and thereby introducing new metaphors [1], we introduce ideas to foster environment-awareness and interactions with the surroundings by turning attention from travel efficiency to environmental engagement and appreciation.

The design principles put forward aim to provide high-level guidance rather than feature-centered design, although we do provide examples for instantiating the provided concepts. Too, we do not focus on usability or aesthetic norms, nor do we attempt to provide an exhaustive list of guidelines. Svahn argues that the development of GPS technology thus far has adhered to classical engineering design, focusing on competitor benchmarking and system integration [26]. Contrasting this trend and given an ethically responsible design approach, we attempt to take into consideration human perception and socio-cultural issues.

One caveat remains: in drawing on the following design principles it is imperative that designers keep driving safety as first principle. Research and design of in-car GPS technology deal seriously with safety issues, and for good reasons; Interaction with in-car devices while driving could result in distraction from the driving task [25], increasing cognitive capture and hindering driving performance [3]. We therefore caution against adoption of the following principles without carefully considering driving performance and safety issues.

We would also like to highlight that these suggestions are inspired by our observations within an US automobile culture – many more and different opportunities would presumably emerge in different cultural contexts.

Design Principles

Navigate by landmarks. Contrasting with GPS-based navigation, users of traditional maps or written directions often determine their location by matching landmarks and environmental attributes [16]. The lack of attention to landmarks is exemplified, for instance, with the account of Informant A, who admitted he never looks at the road signs when navigating with the GPS. As such, GPS instructions could refer to landmarks in aiding navigation. For example, rather than saying, "*Make a right turn in half a mile,*" the message should state, "*Make a right turn in half a mile after passing the state hospital.*" A preview mode may also be useful to present a driver with summary information before

embarking on a journey to familiarize him- or herself with key landmarks on the route. This approach has been studied from a usability perspective [18], and we argue that experiential engagement with the environment could benefit from this principle as well.

Highlight the ambiguity of GPS data. One of the benefits of staying engaged with the environment is to minimize risks associated with over-trusting an automated device. Although GPS data are fairly accurate, there may be inaccurate information due to erroneous or outdated GIS data or blocked reception. In a survey of 872 in-car GPS users, 42% of the drivers said they experienced at least once receiving inaccurate instruction from their devices [12]. An example from our observations is provided by Informant S when what looks like a road on the screen turns out to be an entrance to a parking lot.

GPS systems are designed to normalize fuzzy, incomplete GIS data to present navigation assistance as trustworthy information [16]. For a study of how the display of uncertainty by navigation devices in spite of unreliable and incomplete data can regularize behavior, see [31]. We here also suggest, drawing on Gaver et al's principle of casting doubt on sources to provoke independent assessment [13], that GPS systems should reveal rather than hide error-prone or outdated information to reduce over-reliance. If navigation information is not always presented in an authoritative manner, users may be better prepared to handle unexpected changes to their routes, such as due to a closed road. Voice or text messages on the screen can indicate potential error zones and help downplay the navigation system's authority and make space for reinterpretation [24].

Extend context-aware capabilities. Svahn points out that navigation services primarily address traveling in foreign driving environments, although most driving takes place in familiar areas [26]. He concludes that there is need for a wider range of navigation services tailored for different contexts. In our study, we did find evidence for distinctive usage of the GPS in familiar areas, alas not necessarily for navigation. For instance, Informant H describes the use of the GPS device in marking places that he cares about.

We suggest developing a set of social metadata to detect and act upon a GPS users' familiarity with their environment, for instance, social tags such as home, friend's apartment, office, etc. Based on this contextual information, different features can be offered. As an example, see the routing service proposed by Patel et al. to support personalized rerouting through familiar landmarks [22].

Support the car as a social place. Cars are also places for conversations. Often we drive with our friends and relatives and use the traveling process as an opportunity to engage in social interactions [5]. GPS systems seem to be designed primarily for driver-GPS unit interactions without taking into consideration the likely presence of passengers. Instead of secluding the passenger seated near the driver, who has traditionally been the navigator as in the account of Informant T, we can engage them in the interaction with the GPS unit. Systems can prompt for information to understand if there are passengers in the car and take this feature into consideration in the interaction mode.

BEYOND DESIGN
Up to this point our analysis has largely been device-centered, neglecting the larger socio-technical context of in-car GPS systems. But as Aporta and Higgs argue, what makes the adaptation of a technology such as GPS navigation systems increasingly difficult is the fast pace of technological development, the interlocking of technological systems, as well as the concealment of these interconnections and the operation of devices [2]. Hence a focus alone on analyzing and re-designing GPS units in our cars would be a misguided approach. Instead we need to rethink the larger context of GPS use, the ways we organize our daily lives in urban and suburban environments, the role we want automobiles to play, and how we may foster alternative experiences and practices that favor unmediated contact and skilled engagement with our environment. Below we offer two perspectives that explore the quality and range of changes to current practice that would need to be addressed.

Commodification and De-skilling
In their analysis of GPS replacing traditional Inuit wayfinding methods, Aporta and Higgs locate GPS navigation systems as one element in what they describe as an ecology of technologies that are interconnected, fast changing, and whose components and functions are concealed to provide mobility as a commodity [2]. They see them as an instantiation of Borgmann's device paradigm. Borgmann critiques our technological society at a fundamental level for this dominant way of *"taking-up with the world"* [4]. Technological devices, he argues, exhibit a characteristic internal division between a machinery and a commodity generated by this machinery. To obtain this commodity no skilled engagement with the environment is needed anymore, replacing satisfaction that come with an expertly exercised skill with the comfort of effortless consumption.

As a counter strategy Borgmann suggests nurturing alternative 'focal' practices that can coexist with daily practices in a technological world. These are goods that are one with the practice and can only be obtained through that practice, as opposed to goods and practices that can be commoditized. *"There is a sense of fulfillment and accomplishment in being able to relate fully to the activity we perform and to the environment in which we are. GPS technology takes that experience away, as the response is provided by a mechanism that is hidden, unreachable, and, to most users, incomprehensible."* [2]

Our field study results show a few instances of de-skilling, not only of navigation and orientation skills, but also of social skills. Some of our users reported that they rely on the GPS to find places they want to go to and to get them effectively to their destination. Hence learning to read and

navigate using traditional paper maps, memorizing a route, and maintaining social interactions with others inside and outside of the car are reduced. From this perspective, the problem of disengagement is inherent in the essence of GPS systems as technological devices that commodify, and hence cannot be rectified by any re-design effort. Alternatively, despite a nostalgic tendency to see these instances of de-skilling unfavorably, GPS is a blessing for those who find it hard to acquire navigation skills in the first place.

The challenge remains though to what extent we may use our faculties as researchers and designers to explore new technologies that resist commoditization and trigger awareness for changes in environmental engagement.

Automobilization
Looking at the broader socio-technological context, use of in-car GPS navigation can be seen as the latest element in the general trend of an automobilized society. Thrift describes the factors that allow car passengers to detach themselves from the immediate physical and social environment they are traversing: "*[…] the car becomes a world in itself. Sound and even video systems, climate control, better sound insulation, ergonomically designed interiors, easy recall of certain memories and the like, all conspire to make the car into a kind of monad which increasingly refers to the world outside itself via heavily intermediated representations.*" [28] Or as Urry comments on the specific engagement of the automotorist with their (urban) environment: "*Especially for the non-car-user roads are simply full of moving, dangerous iron cages. There is no reciprocity of the eye and no look is returned from the 'ghost in the machine'. Communities of people become anonymized flows of faceless ghostly machines. […] those living on the street are bombarded by hustle and bustle and especially by the noise, fumes and relentless movement of the car that cannot be mastered or possessed.*" [30]

Here the role of the automobile in detaching its passengers from their surroundings and creating a divide between people is highlighted. The question of engagement with and disengagement from the environment caused specifically by the use of GPS units becomes only one factor in a larger picture. Attempts to remedy issues of disengagement would concern the contribution of the automobile to economic and social life at a fundamental level, and ought to include not only gadget design, but also policy and legislation, urban and road planning, energy consumption, and education.

However, this perspective does not diminish GPS designers' power to promote societal changes. For example, a concealed paradox in exploring environmental engagement factors in using GPS systems is that excessive driving is often cited as a primary cause for pollution. There is an opportunity to embed design elements to remind us of the fragility of our natural environment, and stimulate and inspire reflections on environmental concerns. This could be done by providing an option to display and announce environmental information during a trip – pointing out a bird

refuge, a recycling center, a nearby contaminated lake. Also useful would be additional environmentally-conscious information such as shorter routes, those with lower speed limits, or nearby park & ride facilities to take part of the trip by public transport. Finally, social networking features could be used to promote carpooling by linking users with others who commute in similar routes.

CONCLUSIONS
In-vehicle GPS navigation systems have the potential of affecting the interaction of users with their environment in profound and complex ways. Both our empirical and theoretical analyses demonstrate that use of GPS units alters how people interpret, learn, navigate, and experience spaces and places. We found empirical evidence that disengagement is an issue, and laid out theoretical reasoning to clarify this process. Navigation using GPS is based on abstract representations of spaces and places. We found that with the GPS people become immersed more in the virtual-technological environment and this affects their interaction with the physical environment. This contrasts with ordinary embodied experiences of navigating through spaces and attending to places without GPS.

At the same time, we discovered that the use of GPS adds new dimensions to travel experiences by introducing new tools and expanding our information resources in support of more meaningful, enriched, and genuine travel experiences. Our conclusions are therefore not entirely pessimistic: both our empirical data and theoretical understandings discuss prospects for environmental engagement given GPS use. Furthermore, our proposed design implications are geared toward encouraging involved interactions outside the virtual-technological environment provided by the GPS unit.

Although we do recommend certain design principles, it is important not to focus solely on re-designing GPS devices. We argue that broadening our perspective may enable us to devise strategies that are crucial to address issues of personal mobility and everyday environmental engagement even more thoughtfully.

FUTURE WORK
We see both our field study and theoretical framing as preliminary efforts in understanding issues of environmental engagement and disengagement when using in-car GPS devices. Further research is needed to fully understand the effects of GPS technology in particular, and related interlinked technologies, on our everyday experiences and involvement with the surrounding, physical and social world.

We ought to be aware that grappling with issues of *altered experiences* means that an alternative exists. This alternative refers to *not* using a GPS or *not* using a car. In this study we relied only upon GPS users reflections on their past practices without GPS, as well as imagining themselves back in a non-GPS equipped car. In-car GPS technology is still absent from many cars, constituting a large set of non-GPS users, and there are people not owning a car

at all. Non-users need to be taken into consideration in the design of technologies, policy making and legislation, road planning, and so forth [32].

Another direction to be pursued is to examine issues of environmental engagement and disengagement given other technology devices, such as mobile phones and music and video players. It has been argued that these technologies create a private space within a public space, isolating their users from the surrounding social environment [7,20]. Combining empirical research on these kinds of technologies that support individual mobility in light of the theoretical ideas we present here could promote better understanding on issues of environmental engagement and disengagement in the digital era.

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